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A Portable Data Acquisition and Control System for Waste Treatment Development

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A Portable Data Acquisition and Control System for Waste Treatment Development

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Abstract

Lawrence Livermore National Laboratory (LLNL) has developed a Portable Data Acquisition and Control (PDAC) System that is basically a laboratory-scale Program Logic Control (PLC). This system can obtain signals from numerous sensors (e.g., pH, level, pressure, and flow meters), open and close valves, and turn on and off pumps. The data can then be saved on a spreadsheet or displayed as a graph/indicator in real-time on a computer screen.

The whole PDAC system was designed to be portable so that it could sit on a bench top during laboratory-scale treatability studies, or moved out into the field during larger studies. The system is also fairly simple to use. All that is required is some working knowledge of sensors, control devices, and LabVIEW® software, and how to properly wire the process equipment.

This system has been used during treatability studies on cyanide oxidation, controlled hydrolysis of water-reactive wastes, and other waste treatment studies that enable LLNL to comply with the Federal Facility Compliance Act (FFCAct). Improved data acquisition allows the study to be better monitored and therefore better controlled, and can be used to determine the results of the treatment study more effectively. This also contributes to the design of larger treatment processes.

Introduction

The Lawrence Livermore National Laboratory Waste Treatment Group's (WTG) primary mission is to treat hazardous, radioactive, and mixed waste from on-site operations. In order to devise safe, cost-efficient treatment processes that meet all regulatory guidelines, the WTG conducts numerous treatability studies annually. These treatability studies allow the WTG to obtain the data necessary to determine the overall effectiveness of the proposed treatment process. The data is also used in the design of a full-scale treatment scheme.

In order to facilitate the data gathering the WTG has developed a Portable Data Acquisition and Control (PDAC) System. This system was developed primarily for obtaining data, but it can also be used to control various types of laboratory equipment. The PDAC System had to be portable so that it could sit on a bench top, in a laboratory fume hood, or next to a glove box to connect with generic electrical feedthroughs during laboratory studies, but also rugged enough to be moved out into the field during pilot-scale studies. Flexibility was also required because the treatability studies change frequently.

The Hardware

The PDAC System consists of a computer cabled to a module that holds the power supplies, external signal conditioning boards and all terminal blocks. The host computer is a Power Macintosh 8100/80AV that contains an NB-MIO-16X board for multifunction input/output and a NB-DIO-32F board for digital input/output. The MIO board is configured to provide sixteen channels of analog input and eight channels of digital output and uses a referenced single-ended measurement system. The DIO board is configured to provide eight channels of digital output and twenty-four channels of digital input. Besides the standard printer and modem serial ports, the computer also houses a Hurdler® 4-port serial expansion card.

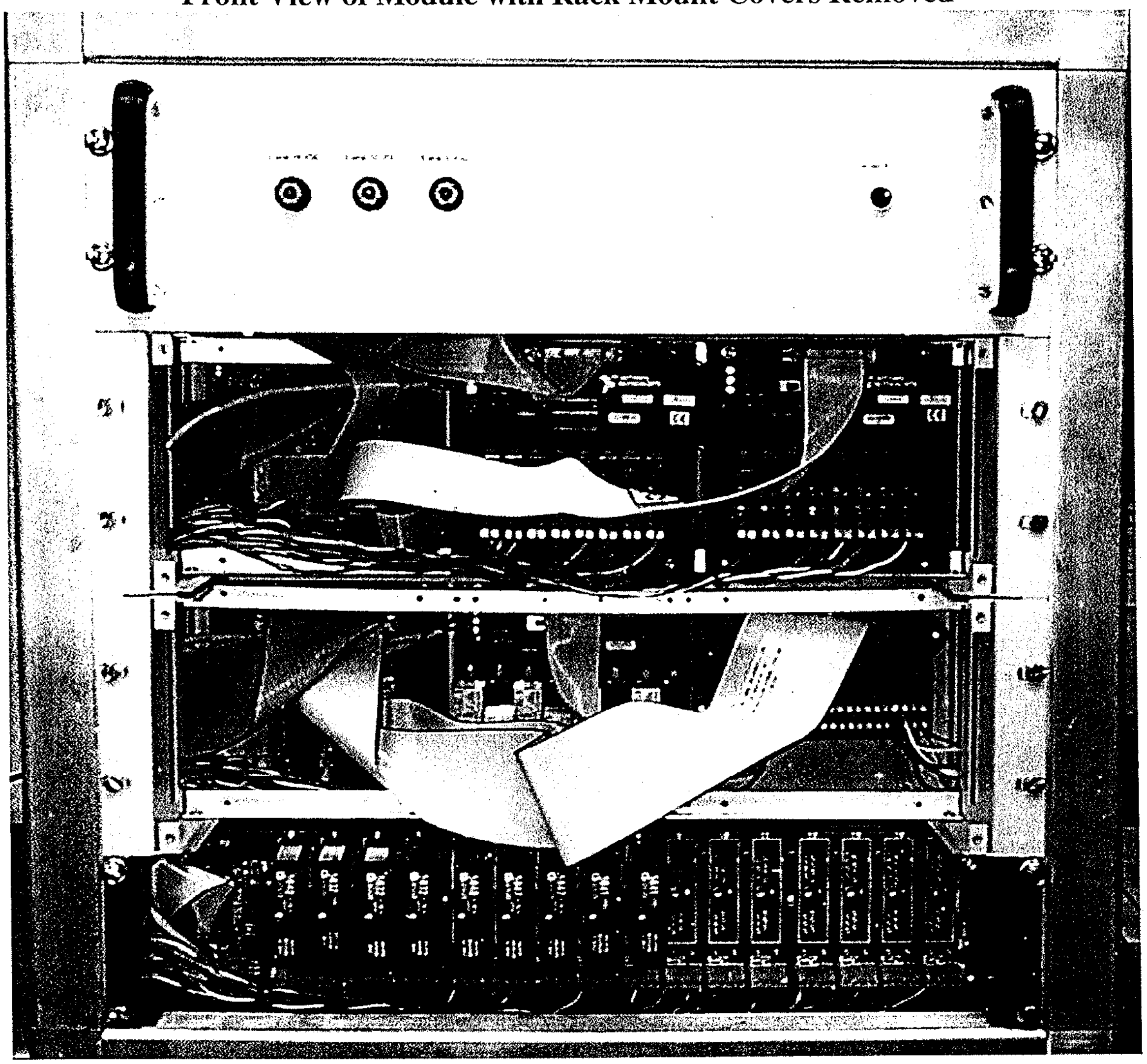
The module is an aluminum constructed box that has dimensions of 22" x 22" x 22". The module weighs around fifty pounds and it has handles on both sides which makes it relatively easy to move around. The module can be plugged into a single standard 110-VAC wall outlet, and supplies +5 volts, +12 volts, and +24 volts DC.

The front of the module, which can be seen in Figure I, is comprised of four rack mounts. The top rack mount houses the three power supplies. The lower three rack mounts house the signal conditioning boards, which are all National Instruments™ boards. The second rack mount contains all five signal conditioning boards associated with the NB-DIO-32F data acquisition board. These DIO signal conditioning boards are comprised of one SC-2052 cable adapter board, one SC-2062 electromechanical relay board and three SC-2060 digital input boards. The third rack mount contains one SC-2050 cable adapter board, one SC-2062 electromechanical relay board, and one CB-50 I/O connector block. The bottom rack mount contains the 5B01 backplane and associated signal conditioning modules. These lower two rack mounts contain the signal conditioning boards associated with the NB-MIO-16X data acquisition board.

The backside of the module, which can be seen in Figure II, is comprised solely of various terminal blocks. The terminal blocks are manufactured by Wago, and fit on 35-mm carrier rails. There are three 15.5" carrier rails mounted vertically on the back plate, which is recessed 4.25" into the module. Black tinted Plexiglas acts as a cover.

The terminal block configuration was designed so that only the analog signal is connected to the 5B backplane. Excitation is supplied using the power supply terminal blocks. This was done to accept sensors with common excitation requirements of 5V,

Figure I
Front View of Module with Rack Mount Covers Removed

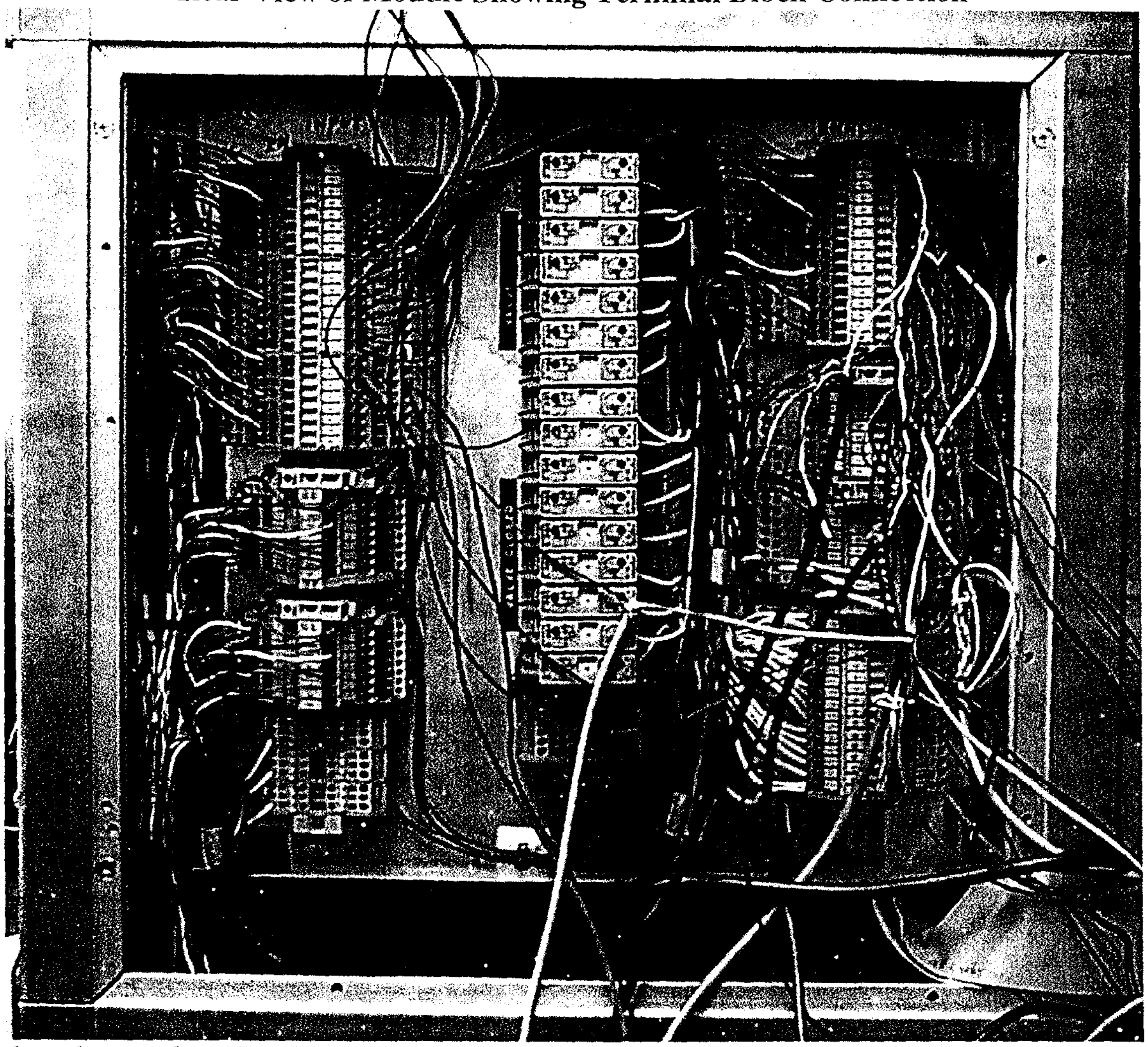


12V, and 24V. The 5B backplane can provide 10V excitation, but this is not flexible enough for most experimental or industrial applications.

There are enough terminal blocks to provide about sixteen outputs per power supply. Also, before the power is connected to the terminal blocks for distribution to the process equipment, it passes through fused disconnect terminal blocks. This is done to protect the individual sensors and also the circuit boards. These fused terminal blocks have an LED that indicates if the fuse has been blown.

For control of valves, this system uses combination relay/terminal blocks to acquire the signal. The valve actuators require +24V-DC power, and send back a +24V signal indicating the valve is open, closed, or actuating. The PDAC System acquires the valve open and closed signals only. When there is a +24V signal from the actuator to the relay,

Figure II
Rear View of Module Showing Terminal Block Connection



the relay sends a+5V signal to the appropriate digital input channel indicating the valve is open or closed.

Sixteen of the digital input channels are for the valve actuators open and closed signals. The other eight are for generic digital input that will be used as needed. The eight channels of digital output associated with the DIO board are specifically for control of the valve actuators, while the digital outputs of the MIO board are generic. All digital outputs are hard wired for +24V-DC power. These terminal blocks also have the fused terminal blocks associated with them to prevent damage to the circuit boards or process equipment.

There is also a terminal block section for the counter/timers of the MIO board. There are three counter/timers that can be used for counting pulses, timing, or pulse generation. If the counter/timers are to be used to count events, then the signal supplied must be TTL compliant.

Software

LabVIEW® is the programming language used with this system. LabVIEW® utilizes a graphical programming environment, which is much like sketching electrical line diagrams. The programs are called Virtual Instruments (VIs), and each VI created can then be used as a sub-VI for higher-level VIs.

The data acquisition VIs developed for this system are fairly simple. They basically consist of three separate parts in a sequence. The first frame is where the spreadsheet file is created and where the column headings are written to the file. The second frame, which is in a continuous loop, is where the sub-VIs are referenced, and the data is acquired and written to the file. When the user presses a stop button, the VI then proceeds to the third frame, where the file is closed, and the VI stops. Developed this way, these VIs are capable of updating each channel about every second.

This software and hardware combination can actually sample multiple channels quicker than this, but the cost is versatility. The PDAC System has frequently changing assignments, which requires the system to be adaptable. Every time the experiment or process changes, the VI must change too. LabVIEW® allows the user to quickly modify the VIs.

Conclusion

The PDAC System has shown itself to be a very powerful tool. By being able to gather much more data than previously capable, it allows all studies to be analyzed in greater detail, and in effect, contributes to the design of a better treatment system. This system would not have been so beneficial if it was not for the fact that it is so easy to learn and use.

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